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a PRODUCTION METHOD WITH ~~PROCESS FOR MANUFACTURING A YARN~~ WITH BREAKAGE DETECTION a FOR A THREAD

The present invention relates to the field of reinforcing fibres and of composites and, in particular, to the manufacture of glass yarns from a multiplicity of filaments.

The manufacture of glass reinforcing yarns is carried out in a known manner from streams of molten glass flowing out of the orifices of spinnerets. These streams are drawn in the form of continuous filaments and then these filaments are gathered into base yarns, which are then collected.

Before they are gathered into yarns, the filaments are coated with a sizing by passing them over a sizer. This coating is needed for obtaining the yarns and allows them to be combined with other organic and/or inorganic materials in order to produce composites.

The sizing serves in the first place as a lubricant and protects the yarns from the abrasion resulting from them rubbing at high speed against various members during the abovementioned process.

The sizing may also provide, especially after curing, integrity of the abovementioned yarns, that is to say the bonding of the filaments together within the yarns. This integrity is especially desirable in textile applications in

which the yarns are subjected to high mechanical stresses. This is because if the filaments are not well fastened together, they break more easily and disrupt the operation of the textile machines. In addition, non-integral yarns are considered to be difficult to handle.

However, the sizing is also employed in cases in which this integrity is not desired, such as in the case of reinforcing fibres, when a high rate of impregnation with the material to be reinforced is desired. Thus, for example in the manufacture of pipes by the techniques of direct impregnation and of filament winding, open yarns are used in which the filaments are separated from each other. Small amounts of sizing, especially of less than 0.5% by weight, are then used.

The sizing also makes it easier for the yarns to be wetted by and/or impregnated with the materials to be reinforced and helps to create bonds between the said yarns and the said materials. The mechanical properties of the composites obtained from the said material and from the said yarns depend in particular on the quality of the adhesion of the material to the yarns and on the ability of the yarns to be wetted by and/or impregnated with the material.

Most sizing compositions used at the present time are aqueous sizing compositions which are easy to handle but have to be deposited in large amounts on the filaments in order to be effective. Water generally represents more than 90% by weight of these sizing compositions, (especially for viscosity reasons), and this requires the yarns to be dried before they are used, water being able to impair the adhesion between the yarns and the materials to be reinforced. These drying operations are lengthy and expensive and their effectiveness is not always optimal; they require the use of large ovens. In addition when they are carried out during the fiberizing operation, (that is to say before the yarns obtained by gathering the filaments have been collected together), they require, at the filaments (WO 92/05122) or at the yarns (US-A-3,853,605), drying devices to be fitted beneath each spinneret and, when they are carried out on wound yarn packages, they carry the risk of irregular and/or selective migration of the components of the sizing into the wound

packages (aqueous sizing compositions already having a tendency to be distributed over the yarns in an irregular manner because of their nature), and possibly of yarn-colouring or package-distortion phenomena. Moreover, package distortion is frequently observed, in the absence of drying, on straight-sided packages (rovings) of fine yarns (that is to say those having a "count" or "linear density" of 300 - 600 tex(g/km) or less) coated with aqueous sizing compositions.

It is in order to remedy these drawbacks that a novel type of sizing virtually free of solvents has been developed, called an anhydrous sizing composition. Anhydrous sizing compositions are curable and/or crosslinkable solutions which possibly contain organic solvents and/or water in small amounts, generally of less than 5% by weight. They are advantageously distinguished from aqueous sizing compositions by their ability to be distributed homogeneously and uniformly over the surface of the filaments, that is to say by forming films of constant thicknesses, and in that they make any subsequent drying or solvent-removal treatment unnecessary since the small amounts of solvent evaporate while the filaments are being coated with the sizing composition and while the sizing composition cures.

Moreover, the amounts of anhydrous sizing deposited on the filaments are considerably less than those of aqueous sizing composition; thus, in depositions by means of a sizing roll, a film forms on the surface of the latter with a thickness not reaching 15 µm in the case of an anhydrous sizing, instead of a film of approximately 90 µm in thickness for an aqueous sizing. These smaller amounts of anhydrous sizing are moreover deposited on the filaments with a greatly superior efficiency, possibly up to 100% when the operating conditions are judicially chosen, whereas this efficiency is generally of the order of 40 to 75% with aqueous sizing compositions.

Anhydrous sizing compositions fall mainly within three categories.

The first covers UV-curable sizing compositions, such as those described in Patent EP 0,570,283 and comprise, for example:

- at least one monounsaturated or polyunsaturated monomer and/or oligomer of the type including polyester acrylates, epoxy acrylates, silicone compounds and urethane acrylates;

- at least one photoinitiator, such as benzoin, acetophenone, benzophenone, sulphonylacetophenone and derivatives thereof, as well as thioxanthones;

- where appropriate, at least one organic solvent; and optionally

- additives such as at least a wetting agent, an adhesion promoter, an antishrinkage agent and a bridging agent consisting especially of a silane.

The second family of anhydrous sizing compositions is that of thermally curable and/or crosslinkable sizing compositions, such as those described in Patent Applications FR 2,713,625 and FR 2,743,361.

By way of example, the basic system of these compositions comprises:

- an acrylic constituent and a thermal radical initiator peroxide;

- or an epoxy constituent and an anhydride constituent which cure by reacting with each other.

The third category of anhydrous sizing compositions forms part of the teaching of application FR-2,763,328; these are sizing compositions that cure at room temperature, the base systems of which may contain one or more homopolymerizable monomers and/or at least two copolymerizable monomers requiring no external supply of energy. If the two monomers or monomer mixtures are copolymerized, they may be deposited on the filaments in the form of their mixture in solution, immediately after this mixture has been formed, or in the form of a first stable solution containing the first monomer or monomer mixture and of a second stable solution containing the second monomer or monomer mixture. In the latter variant, the first solution is applied to the filaments and the second subsequently, at the latest during the gathering of the filaments into yarns. Whatever the case, the copolymerization generally starts as soon as the first and the second monomers or monomer mixtures and, where appropriate, the required catalyst or catalysts come into contact with each other on the filaments.

The UV exposure treatments and the heat treatments required for curing the sizing compositions of the first two types mentioned above are carried out in one or more goes, after the filaments have been gathered into yarns. Depending on the envisaged use and on the nature of the yarns, an irradiation or heating pretreatment is thus sometimes carried out at the time of collecting the yarns into the various packaging forms so as to precure the sizing, the actual curing of which is carried out in a subsequent irradiation or heating treatment when the yarn is unwound for the purpose of putting it to the specific use for which it is intended, namely as a textile or for reinforcing organic or inorganic materials. This is because the yarn coated with the as-yet-uncured composition does not have an integrity in the ordinary meaning of the term, since the sheathed filaments making up the yarn can slide over one another. This yarn can therefore be easily handled and, when it is wound in the form of packages, can be easily extracted from the packages without having been subjected beforehand to a treatment to cure the sizing. Moreover, the yarn coated with the as-yet-uncured sizing composition can be very easily wetted and impregnated by materials to be reinforced, the impregnation thus being able to take place more rapidly (increase in productivity) and the composites obtained thus having a more homogeneous appearance and certain mechanical properties improved.

However, as described in Patent EP 0 570,283, the curing of the sizing, by UV irradiation of a yarn in the form of a package may also have advantages.

One of the problems arising most acutely during the manufacture of yarns consisting at least partly of glass is that of breakage, which it is desired to avoid as far as possible. In fact, when one or more of the filaments intended to form the yarn start to break, serious consequences rapidly arise. Firstly, it should be stressed that the sizing which covers the filaments acts as an adhesive; when a filament thus covered with sizing breaks, the greater tendency it has to adhere to all the elements with which it comes into contact the stickier it is. There is a risk of it being entrained in the various rotating mechanisms, of causing other filaments that have hitherto retained their integrity to be pulled out and of

resulting in the formation of packages liable to cause deterioration of the elements for depositing sizing, such as felts or doctor blades, or of scratching the surface of the sizing rolls.

Moreover, a fracture of one or more filaments has as another serious consequence the formation of drops of molten material, especially drops of glass, which, when they fall, constitute a fire risk, for example by the more or less spontaneous ignition of the sizing composition, particularly in the case of anhydrous sizing compositions. Moreover, drops of molten filaments falling onto the sizing roll damages its surface, to the detriment of uniform deposition of sizing and possibly causing more breakages after subsequently restarting.

Another problem arises when the breakage occurs in the peripheral filaments; the dynamic balance of the system is then relatively undisturbed, so that the fiberizing and the winding may continue by producing a finer and finer yarn. The consequences of this may be quite serious, especially in the case of a roving intended for the production of a fabric or of a mesh for which a certain mechanical strength is required, such as a support mesh for abrasive grinding wheels.

Consequently, it is important to detect the breakage of the first filaments as soon as possible so as to take measures making it possible to avoid the occurrence of problems that have just been described or the destruction of elements containing polymers such as hoses, electrical wires, sensor components, etc. These measures may consist in stopping the sizing roll, in closing the protective cover on the sizing roll, in stopping the winder, etc.

For this purpose, the subject of the invention is a process for manufacturing a continuous yarn, in which a multiplicity of continuous filaments is formed by the mechanical drawing of a multiplicity of streams of molten thermoplastic(s) and these filaments are gathered into at least one yarn. This process is distinguished by the fact that the tension exerted by a combination of some or all of these filaments is permanently monitored by detecting the transition of this tension to below a predetermined value. This value is to be chosen case by case according to the invention, so as to indicate the breakage

of the smallest possible number of filaments but with a virtually absolute degree of certainty. This therefore requires a high detection sensitivity, requiring the use of extremely accurate set-ups and adjustment and/or of special detectors, which are themselves very accurate.

According to one particularly practical embodiment of the invention, the monitored tension is exerted by the abovementioned combination of filaments on a castor having a peripheral groove in which they are engaged. This is opportunely the gathering castor in the groove of which a multiplicity of filaments of different and converging incident directions engages, in such a way that they form a single strand - an intermediate product in the manufacture of the yarn.

There are various ways of linking the combination of filaments, the tension in which is to be monitored, to the means for monitoring this tension.

According to a first variant, the combination of filaments is linked to a lever in such a way that the latter pivots when the monitored tension passes below the predetermined threshold value, a magnetic detector then being actuated. This variant is illustrated in detail in the description of the drawings below.

The second and third variants advantageously allow the use of an almost stationary gathering castor; such a characteristic has, in particular, the great advantage of making it easier for the machine to be restarted compared with that obtained with the first variant above. Not only does this type of embodiment of the process prevent any rotation of the castor, but it also renders any other movement thereof barely reactuatable because of the presence of the auxiliary apparatus with which the castor is necessarily equipped, such as ducts, sensors, spraying and restarting system, etc. Thus, according to a second variant and a third variant, the tension in the filaments is monitored by means of a strain gauge working in bending, alternatively in torsion. A strain gauge is able to detect very small variations in strain.

Advantageously, as explained above, the gathering castor is then mounted so as to be virtually stationary on a shaft. In one case, the strain gauge

is mounted longitudinally with respect to the shaft in such a way that it is subjected to a bending force when filaments break, causing a variation in the tension exerted by the combination of filaments on the gathering castor. In the other case, the shaft is able to undergo a very slight rotation, imperceptible to an observer, and the strain gauge is mounted coaxially with respect to the axis of this rotation in such a way that it is subjected to a torsional force when filaments break.

The use of a strain gauge working in torsion according to the third variant advantageously makes it possible for the tension in the yarn to be actually measured continuously. This is not possible according to the second variant, in which the detected force includes a frictional component liable to vary according to complex criteria.

According to the most common embodiment of the process of the invention, all the filaments constituting the yarn are glass filaments. However, the invention does not exclude the variant in which the yarn consists of glass filaments and of filaments made of a second thermoplastic, especially an organic thermoplastic. Only the glass filaments may then be provided with a coating of sizing or of a first sizing constituent, the organic filaments being coated with a second sizing constituent, optionally able to react with the first constituent. The term "organic filaments" should be understood to mean thermoplastic polymer filaments, such as polyolefin (polyethylene or polypropylene), polyamide or polyester filaments. These polymer filaments may be projected between the already sized glass filaments, before all these filaments are gathered into a yarn, as described in Patent EP-0,599,695.

Further features and advantages of the invention will appear in the description which follows of the appended drawings, in which Figures 1 and 2 show one embodiment of the first variant of the process mentioned above, in the absence or in the presence of filament breakage.

A gathering castor 1 has a peripheral groove 2 in which it receives a multiplicity of filaments of converging directions coming into a strand 3. The castor 1 is mounted so as to pivot on a shaft 4 which itself pivots with respect to

a spindle 5 located in a casing 6. The latter is fastened in a manner corresponding to a position of the sheet in Figure 1, with the major axis horizontal (which position will be retained in the explanations which follow) and with the longer length taken upwards, that is to say in the offset position of the spindle 5 with respect to the vertical direction. The shaft 4 includes, on the spindle 5, a metal tab 7 approximately perpendicular to the shaft 4. Moreover, a magnetic detection cell 8 is fitted in the casing 6. When the tension exerted by the filaments of the strand 3 on the castor 1 is at least equal to a fixed value depending on the weight and on the configuration of the elements of the device, that is to say when, for example, all the filaments of the strand 3 have retained their integrity, as shown in Figure 1, the force applied by the strand 3 to the castor 1, directed upwards and to the right in the drawing, compensates for the weight of the castor so as to stop the shaft 4 in the position shown in Figure 1, in which the metal tab 7 is placed opposite the cell 8. On detecting the tab 7, the cell delivers a voltage of 10 volts.

On the other hand, when such a number of filaments breaks so that the tension exerted by the strand 3 becomes less than the aforementioned fixed value, the reactive force applied by the strand 3 no longer compensates for the weight of the castor 1 and the shaft 4 pivots clockwise so that the metal tab 7 is shifted out of the detection field of the cell 8. The latter then delivers a voltage of 0 volts, actuating functions such as the stopping of the sizing roll, the closing of the protective cover on the latter, the stopping of the winder onto which the yarn obtained is wound, etc.

The invention therefore makes available a process in which breakage of the yarn is detected very early, as soon as the first filaments break and in any case well before the entire strand breaks, so that measures can be taken to avoid the problems resulting from the breakage (the entrainment of fibres into rotating mechanisms, the propagation and magnification of the fibre pull-out phenomenon, the deterioration of the rotating mechanisms, fire, etc.) becoming too serious.